ART. VI.—*The Geology of Castlemaine, with a subdivision of part of the the Lower Silurian Rocks of Victoria, and a List of Minerals.*

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(With Plate VI.)

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The discovery of the graptolite succession in the Castlemaine rocks has already been briefly indicated by myself in a short paper contributed to the Adelaide meeting of the Australasian Association towards the close of last year. In the present communication I propose discussing the geology of the district in more detail, and adding a few observations which have since then come under my notice.

In 1853 Sir Arthur Selwyn, then Director of the Geological Survey of Victoria, examined the district, and made a traverse of its northern part from the Campaspe to the Loddon, passing through Mounts Alexander and Tarrengower. He published a sketch map, and a section along the line mentioned, and briefly described the physical features and the rocks of the district.* Since then the most important work done has been the mapping, by Mr. Geo. Ulrich, of a large extent of country from Harcourt to Mount Franklin, and from Maldon to Elphinstone, on a scale of two inches to the mile. Selwyn, in one of his reports,† gives some interesting details of the work involved in the preparation of these quarter-sheets. He says: "In the construction of the Castlemaine sheet alone over 300 miles have been traversed solely to lay down topographical features, exclusive of the contouring requisite for hills. Three thousand holes have been

* Papers presented to Parliament 1853-4, vol. ii.—Reprinted in Q. J. G. S., vol. x., 1854.
† Geological Surveyor's Report, 1861.

sunk to ascertain the depth of the drift. Eighty-one holes, aggregating 827 feet, have been sunk to ascertain geological boundaries and for prospecting." With regard to the hill-shading and the topography generally, the maps are marvellously accurate. Every little rise and gully is exactly shown, and I have been constantly able, map in hand in the field, to mark my position accurately to within a few yards. Without these maps I should have been quite unable to make any progress in unravelling the stratigraphy of the district, as it would have been beyond my skill to have constructed a map, in such difficult country, which would have been of any use for detailed work.*

The town of Castlemaine lies on the chord of the arc which forms the southern boundary of the horse-shoe-shaped area of granite extending from Elphinstone through Harcourt, to a few miles south of Maldon.

The Granite.

The area occupied by granite is, in the main, gently undulating, with a few scattered tors and bosses of rock. Occasionally it rises into lofty hills, of which Mount Alexander (2435 feet) is the highest point of the principal range. At the Harcourt granite quarries a fine face is exposed. The rock, so well known in Melbourne as a building stone, needs but little description. Normally it is a grey, fairly fine grained rock. Occasionally, red felspar occurs and gives it a pinkish tinge. Small patches of fine grained rock with more abundant black mica occur having a very definite outline. These are probably concretionary, as is stated to be the case with similar patches occurring in Cornwall.† Patches of very coarse grained rock occur at times, and on one visit to the quarry I noticed traces of a gneissose structure. Euritic dykes occur, but I have not seen any more than a few inches in thickness. Druses or Vughs are rare at the quarry, but one which occurred was lined with beautiful crystals of what Mr. O. Rule, to whom I submitted specimens, identified as Stilbite and Albin, the latter mineral a variety of Apophyllite.

* The mile posts as marked on the quarter-sheets show a difference from Melbourne too great by about six chains. This is probably due to a deviation made at Kyneton, and the error will probably hold as far south as that township.

† A. J. Phillips, Q. J. G. S., vol. xxxi., p. 1.

not having been previously recorded from Victoria. These minerals were accompanied by crystals of orthoclase and smoky quartz. Iron and copper pyrites occur in small patches associated with minerals derived from them by alteration. I have also noted garnet and schorl from this locality. Jointing is well marked and, in the quarry, is very regular. One set of joints strikes E.5°N., another about north, both being nearly vertical; while a third set, forming the "floor" of the quarry, "dips" at an angle of about 20° to the westward. The exact agreement of the north striking joints, with the strike of the silurian rocks, is peculiar.

Near the silurian boundary, the character of the rock is more varied, and may be well studied near the Expedition Pass Reservoir, where the Sutton Grange Road passes through a cutting in the silurian almost on the boundary. Here, numerous granitic veins, of very varied character, may be seen cutting through the sedimentary rocks. Schorl is abundant, but good crystals are rare. Graphic granite is common, and fine specimens may be gathered of all degrees of texture. Leptynite also occurs, containing occasionally garnets of small size. Altogether the road-cutting in about fifty yards shows about a dozen dykes, varying from twenty feet to a few inches in thickness. The largest dyke consists of ordinary grey granite much decomposed. Another contains large plates of white mica and orthoclase crystals an inch and a half in length, the quartz being much larger. One aplite dyke, five inches in width, can be traced for about twenty yards with a strike S.40°E. The dip and strike of the silurian rocks here is normal. Another locality, where the junction may be studied, is in the road cutting under the railway bridge at Harcourt, where similar features are shown. At the point where the large water-race from the Coliban passes the junction at Elphinstone, the surface soil is too deep for observations, other than that afforded by change in colour, to be made. The spot is about one hundred yards south of the point where the Bendigo railway crosses the race, and may be seen from the train. At Maldon, north of the brewery, the actual contact may be seen in a creek section. Here the crumpled silurian rocks dip into the granite which is seen to over-lie them for several feet, having evidently been forced there while plastic.

At Bradford, a few miles north of Maldon, and well within the granitic area, many interesting minerals have been found as described by Mr. Geo. Ulrich*. Mr. J. Hornsby, of Maldon, has a splendid collection of these minerals, several of the figured crystals being in his possession.

The Silurian Rocks.

Mr. R. Brough Smyth's description of the physical features of the palæozoic rocks of Victoria is peculiarly applicable to Castlemaine.† He says, "The course of the main streams nearly everywhere conforms to the strike of the rocks. The tributaries of the rivers are at right angles to them; and this system of drainage extends to the smallest basins. The configuration of the surface consequently is in many places curiously symmetrical. Running parallel with the main streams, we see two ranges of hills with subordinate ranges at right angles to them; and from every little range, oblong spaces of land, ending in low rocky prominences, run down towards the creeks."‡

Though the north and south valleys are in accord with the strike of the rocks, they show no constant agreement with the position of anticlinal axes, but, as we should expect in beds of such varying texture, scoop their courses out of the softest rock, and may work east or west towards its dip. Consequently the ridges are usually of sandstone, and as the gullies are steep-sided, an accumulation of loose blocks on the slopes and in the bottoms of the valleys occurs, and is apt to produce an impression that arenaceous beds form almost the whole of the series.§ The cause of the east and west valleys is probably to be found in jointing. The long west bend of Forest Creek, below Chewton, does not occupy a fault, as the anticlinal line passing through Monument Hill can be traced for a long distance to north and south, and shows no displacement near the creek.

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* Exhibition Essays, 1886; also Contributions to the Mineralogy of Victoria, 1870.

† Goldfields and Mineral Districts of Victoria, p. 42.

‡ See also Smyth Ex. Ess., 1866, p. 6.

§ Mr. Wm. Nicholas, during a series of lectures delivered in Bendigo, says, "in Castlemaine sandstones preponderate." These valuable lectures are reported in the *Bendigo Advertiser*, *Independent*, and *Evening News*, between February 11th and August 26th, 1881.

Selwyn* and Smyth† point out that surrounding the granite area of the district, the indurated silurian rocks usually form a range of steep and rugged hills. It will be noted that the Elphinstone and Big Hill railway tunnels are through these hills, while at Harcourt and near Maldon advantage has been taken of water courses to cross the boundary.

The rocks consist of slates and sandstones of all varieties of texture. The coarsest grit observed occurs near the head of Victoria Gully about the strike of the Corporation quarry and is exposed in the race. The quartz grains are about an eight of an inch in diameter and well-rounded. A similar grit occurs on the hills north of the head of Moonlight Flat, where it projects like a rampart twenty feet in height, and is traceable for a long distance. A peculiar conglomerate occurs near the seventy-third mile post on the Bendigo railway. It consists of a fairly fine-grained sandstone, in which are embedded rounded fragments of slate. One of these fragments was seven inches long and one inch thick. A similar rock occurs half a mile nearer Melbourne, and also in the creek cutting above the Francis Ormond Mine, at Chewton. Mr. E. J. Dunn‡ records a similar rock from Bendigo. A conglomerate, noted by Ulrich, occurs in the Brewery Gully, Maldon.

Some of the sandstones show a concretionary banded colouring which has a strikingly beautiful appearance. One set of beds of this description crosses the railway line at the Chewton station, being repeated several times by folding, and is traceable north as far as Donkey Gully. The same band recurs in the cutting at Scott's Hill, a mile and a half to the westward, and possibly again in New Chum Gully. Quartzites occur plentifully, usually in rather thin bands, and quartzose rocks which approach them in character, but are ferruginous, are common all over the field.

The argillaceous rocks are all more or less cleaved, and I have consequently classed them merely as slates. Mica is rarely present in the slates, though frequently so in the sandstones, some of the latter being thickly spangled with plates of a whitish variety of that mineral.

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* Parl. Papers, and Geol. Mag., *loc. cit.*

† G. F. and Min. D. Vic., p. 70.

‡ Rep. Bendigo Goldfield, p. 6.

As we approach the granite traces of metamorphism become more pronounced. Flaggy sandstones and quartzites are well-developed, while the more argillaceous beds exhibit the appearance of knotted or nodular slates *(fruchtschiefer).* The bye-wash of the Expedition Pass reservoir displays a fine section. The rocks here are more than usually contorted, and vertical as well as horizontal sections can be seen showing clearly the effects of "pitch," or dip of an anticlinal axis. The nodules of these slates are rarely more than an eighth of an inch in length, and frequently smaller. They are sometimes harder, sometimes softer, than the surrounding rock, usually they differ in colour from the matrix and have the appearance of carraway seeds embedded in the stone. One specimen from here showed white crystals, probably of andalusite. I have not seen any true mica schist.

Judging from the notes on the quarter-sheet (9 N.W.) a somewhat metamorphic band runs far to the south between Taradale and Fryers. The ranges on this band are very rugged, and form a part of the spur of the Divide, which Brough Smyth alludes to as running north from the Blue Mountain through Mount Alexander.

The dense, blue quartzitic sandstone of Maldon is called "Hornfels," by Ulrich. Locally, it, like a softer rock from Castlemaine, is known as "bluestone," and is used for road metal. Owing to its brittleness it is far inferior to the softer but tougher basaltic "bluestone" which is used elsewhere.

The building stone of the district, a soft brown argillaceous sandstone, is of a very variable character and blocks of good quality are a rarity. The older buildings are in a ruinous condition from the exfoliation of the stone, brought about by the decomposition of disseminated pyrites. It is quite unsuited for ths purpose to which it is applied, though unfortunately the new bridges over the creeks are built of it.

Cone-in-cone structure is rare in the rocks, and the only good specimen I have seen was in sandstone, and not in the usually quoted carbonate of lime or of iron. The specimen was found by Mr. James Shugg near the Devonshire Mine, and subsequent search has failed to bring any more examples to light. I found a peculiar example of an allied structure near the Chinese Joss

House, below Patterson Bridge. The surface of the rock, an olive slate, was closely covered with flat oval depressions about one-fourth of an inch in diameter. In some cases, on these depressions were seated small cones about one-eighth inch in height, of a whitish colour, finely transversely striated and longitudinally more deeply gooved, and having somewhat the appearance of sessile barnacles. The flat bases were downwards, and on the cleavage planes. The apices of the cones were embedded in a softer clay, and as no trace of obverse cones was visible the name cone-in-cone will not apply. The structure is undoubtedly not organic, and Mr. Newberry, to whom I sent a specimen, submitted it to Mr. Howitt, who informs me that he considers it to be of a concretionary nature. I have seen several less perfect examples, where the cone bases if not carefully examined would perhaps be considered rain-prints, and from the cleavage making the depressions deeper on one side than on the other the direction of the wind would doubtless be inferred.

Some of the blue and grey slates are thickly marked with red oval patches, mainly on the cleavage planes. Frequently a small speck of limonite in the centre shows that a grain of pyrites has yielded the colouring matter which has spread out through the rock in the easiest direction. Small oval films of pyrites were also observed in slates at the Devonshire Mine, which on decomposition would yield the same appearance.

Limestones are apparently absent, though Mr. Dunn* records a narrow band of black limestone from similar rocks at Bendigo. The presence of lime in the beds, is shown by the occurrence of strings and patches of magnesian limestone, in joints of the slates near Patterson Bridge, and at the south end of the Barker's Creek slate quarry. The frequent occurrence of calcite and allied lime-bearing minerals in the quartz veins points to a similar conclusion.

Slaty cleavage, as before mentioned, is strongly developed all over the district, and has a strike coincident with that of the beds. Over the western part of the field, the dip of the cleavage is about 80° to the westward, but whether this direction holds for the Maldon side of the district, I cannot say. In the railway cutting, on the Elphinstone side of the tunnel, the quarter-sheet

* *Op. cit.*

has the cleavage marked at 50°. After a careful examination of this section, I feel bound to conclude that the bedding and cleavage have been confused, as the bedding is clearly seen throughout the whole length of the cutting, and that the usual high angle of cleavage is maintained. Cleavage is rarely well shown in the immediate neighbourhood of anticlines and synclines. The rocks tend to become rubbly and frequently a system of close set radial joints is developed. These joints are well displayed in many of the railway cuttings; for instance, in a syncline 200 yards west of the Elphinstone tunnel. Mr. E. J. Dunn* regards this structure as cleavage, and states moreover that the direction of the dip of cleavage varies at Bendigo, but that an easterly dip is more common than a westerly one.

There must of course, in such contorted beds as we are dealing with, be places in which cleavage and bedding coincide, but I have met only one instance of such. This is in the Barker's Creek slate quarry, where the beds dip westerly at more than 85°. Mr. Reginald Murray† says, when speaking of our silurian rocks, that "stratification and cleavage are generally identical, but cleavage distinct from stratification is not uncommon." Ulrich‡ states that the cleavage "frequently very nearly coincides with the planes of stratification." As I have searched for graptolites all over the district, the divergence of cleavage from stratification has been brought home to my mind very strongly. When the two differ much in direction, as when the beds dip east and cleavage is strongly developed, a long time has frequently to be spent in search of indentifiable fossils, till by chance a specimen is found the long axis of which accords with the strike of the rocks.

Jointing is of course usual, and well developed, in most of the sandstones. Owing to the joints being close, large blocks of stone are rarely obtainable, and frequently the sandstones are rubbly. Occasionally, as shown at the east end of Lyttleton Street, the joints are so well and evenly developed that the arch appears to be built of masonry.

Faults.—Strike-faults, as seen in the cuttings are very common,

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* *Loc. cit.*, p. 14. † Geol. and Phys. Geog. Vic., p. 41.

‡ Catalogue of Rock Specimens in Tech. Mus. Melb., 1875. Printed in Parliamentary Papers, and also issued separately).

and a small thrust-plane is shown on railway line just to the east of the Ten Foot Hill bridge, the amount of displacement being about four feet. Dip-faults I have not detected on the surface. By the miners they are known as "cross-heads," and frequently cut off the reefs or quartz veins. Diagonal faults, or "counters," "caunters" or "quonters," as the miners call them, also occur, and in some cases, as in the "No Name Reef" to the south-west of the Crown Nimrod Mine, are occupied by auriferous quartz veins. Slicken-sided rock is plentiful, and I have found well-polished faces of quartz from fault walls. The quartz veins usually occupy faults which generally have opened along the bedding planes. In the creek, to the east of Mr. James Newman's house, a block of sandstone contains small seams of slate and in these slates are many small seams of quartz, which have formed between the cleavage planes, and do not pass into the uncleaved sandstone. Selwyn* states that the large quartz reefs often occupy a similar position. "Saddle-reefs," such as occur at Bendigo, appear rare, and but few reliable instances are recorded. These reefs (formed as Mr. Wm. Nicholas, Mr. E. J. Dunn, and others have minutely described, in cavities produced on the anticlines by the unequal bending power of the various rocks) which are the source of the greater part of the Bendigo gold, are frequently reported in this district from the most impossible places. One mine in particular, during my residence in Castlemaine, reported having struck a "west-leg" of such a "formation" and were cross-cutting east to strike the other leg, which they professed to expect at a very short distance, while, as a matter of fact, the anticline on which alone such a reef could be formed lay at a distance of over 300 feet away. Fortunately, of course, gold occurs plentifully in reefs which are not "saddle-reefs," and "saddle-reefs" are just as likely to be non-auriferous as any others. A small "saddle-reef" was struck in the Ajax mine on the anticline about sixty feet east of the shaft, and another occurs on the Daphne reef anticline in Lost Gully. Many of the mines of the district are near anticlines, but quite as many, if not more, are far from them. As an example of the former, we may note the Devonshire mine, and the eastern shaft

* Ex. Ess., 1866, p. 13.

of the South Wattle Gully Co.; while the once fabulously rich mines on the other side of Wattle Gully, are as near to a syncline as to an anticline. The Bolivia reef occupies a fault with a western hade, the country rock dipping east. The country in the neighbourhood of quartz reefs is usually so disturbed that observations of dip are unreliable in these localities.

Rock folding.—The whole series of rocks is much folded and crumpled. Hand specimens may be gathered which show the folding on the most minute scale and such crumpled rock generally occurs near the axis of one of the larger anti- or synclines. To this puckering, I feel constrained to put down most, if not all the instances quoted, of "ripple marks" in our silurian rocks. Two such instances may be noted. Mr. E. J. Dunn* speaking of the Bendigo "saddle-reefs," describes the rock slipping that must have taken place during their formation,† and then notices that one wall of the original cavity shows ripple-marks beautifully developed, that is, just at the place where rock-slipping must have been greatest. The other instance occurs in the bed of the Moonee Ponds Creek, near the Park Street bridge. In this case also, there has been considerable rock movement, for the bed which shows the marks is about eighteen inches below a thrust-plane, which is accompanied by shattered rock, and small veins of quartz. Innumerable other instances may be quoted, but when we are dealing with rocks like those of Castlemaine, which have an average dip of over 70°, or of Bendigo with one of 65°, the simplest explanation seems to be that the structure is a form of crumpling, for were it otherwise, its observance would be a rarity instead of one of the commonest of occurrences.

The larger anticlines succeeded each other very rapidly, the average distance being 300 yards. In the water-race from Chewton to Castlemaine, along the hill slopes to the south, I have plotted thirteen in two and a half miles. This agrees closely with what occurs at Bendigo.‡ The anticlines can be traced for long distances. For instance, I have traced the anticline through Monument Hill for two and a half miles. The anticlines have a fairly constant strike of N.5°W. Owing to the way in which

* *Loc. cit.*, pp. 6 and 12.

† See also Wm. Nicholas, F.G.S., in *Bendigo Advertiser*, and *Bendigo Independent*, August 27, 1881, for similar explanation.

‡ Dunn, *loc. cit.*, plan.

they die away and are replaced by others, the folds may be compared more with sea-waves than with anything else. The Ajax anticline may be taken as an illustration. A well-marked anticline may, as before mentioned, be seen about twenty yards east of the shaft, the strata dipping east and west for some distance from the axis. This axis may be traced, with but a small intermission, caused by a gully crossing it, as far north as the Maldon railway line. Here, as shown in the cutting, it has almost disappeared, and is merely represented by a slight roll in the strata, the main dip being westerly. Still further north, in the cutting in front of the Church of England Parsonage, its only trace is a crumpling of the slates. The anticline to the eastward is now the main one. Near the Ajax it is scarcely, if at all, noticeable. Its axis is shown at the south end of Barker Street, and it passes through the Corporation quarries in Bull Street, near the railway line, and it is now an important fold.

Besides this dying away of anticlines, it is of course the rule in disturbed rocks that the axes of the folds are rarely horizontal. Owing to the peculiar structure of the Bendigo "saddle-reefs," and the great extent of the underground workings, Mr. Dunn and the mining surveyors have been enabled to work out the "pitch" or dip of the axis very thoroughly. Similar facilities do not occur in Castlemaine, but in a few instances the top of an arch is sufficiently bared to enable observations to be taken. The most striking example I know occurs near the head of Sailor's Gully,* the gully next to the north of German Gully. (The exact spot is a few yards west of a quartz reef, as shown on the map, crossing the valley). At first sight it appears like a dip-fault, as two parallel bands of sandstone occur with a strong outcrop. In reality, however, they belong to distinct beds, and their disappearance north is caused by a "pitch" of about 40° and the bands curve round as they "nose-in" on the flat. This is the highest "pitch" I have noted, but Mr. Dunn records one of 60.°† As attention has only recently been called to the effects of pitch on the structure of our goldfield areas by Mr. Dunn, perhaps a few localities had better be recorded where it can be studied in this district. The anticline at the east end of Lyttleton Street pitches 13° to the southward; another on the east side of Wattle Gully,

* ¼ S., 13 S.W. † *Loc. cit.*, p. 12.

about 100 paces south of the S. W. G. Co.'s eastern shaft, pitches 12° N.; another, south of the Campbell's Creek Road, just above where Dead Horse Gully joins the creek, pitches 12° N. and is a fine example. Mr. H. W. Green, legal manager of the Ajax Co., read me the mining manager's reports for 1890, from which it appeared that the anticline previously noticed in that mine carried at the 900 feet level a small saddle-reef. This was "driven on" north, for some distance, and, after undulating slightly, finally took a strong northerly pitch and passed underfoot. Out of a total number of eight instances, in which I have recorded pitch in my notes, seven showed a northerly inclination, and the palæontological evidence seems to point to a general northerly pitch of all the rocks to the east of Castlemaine. Professor J. D. Dana* points out that in order to get a thorough knowledge of the pitch of strata in any disturbed district, thousands of dips must be accurately plotted, a labour from which, for many reasons, I have shrunk.

Dip.—Over the eastern portion of the district, from Barker's Creek to the granite, there are numerous good exposures and dip can easily be observed. From Elphinstone to Chewton the railway cuttings give an almost continuous section; while from Chewton a water-race extends along the hill-sides as far as the Ajax mine. To the westward of Barker's Creek the country is more deeply masked by surface soil, the gullies are fewer and of less importance, and the scrubby timber is thicker, so that I was unable, after several futile attempts, to make any satisfactory number of observations. The Maldon railway line has such shallow cuttings that, for that part of the field, I have had in great measure, to fall back on the recorded observations of others. In railway cuttings, where nearly vertical beds are cut obliquely to their strike, the slope of the cutting gives an apparent dip in different directions on opposite sides, and on hill-slopes especial care must be taken, as surface slipping renders all observations except on a north or south slope of little value.

From Elphinstone, nearly to Chewton, the dip, owing to constant inversion is westerly, and the bending over of the beds can be well traced in many places. In the deep cutting at the west end of the tunnel a fine anticline is displayed in grey

* *Nature*, vol. xlvi., p. 154.; also Amer. Jour. Sci., June, 1892.

sandstone, and is best seen from the top of the cutting on the south side. East of the anticline the beds dip more and more steeply to the east, and at about thirty paces have completely turned over, and dip west. The syncline near the drain, about 150 yards west, behaves similarly, so that a constant westerly dip holds throughout the cutting. The next cutting to the west is still more interesting. It is 350 yards long, and about thirty feet deep for most of its length. An anticline occurs 180 yards from the west end, and, as the rocks are shattered in its vicinity, some care is requisite for its detection. For a few yards east of the anticline the beds have a high easterly dip, then become vertical, and finally turn over with a westerly dip of about 75°, which is maintained to the end of the cutting. The variations in the texture of the beds are great, but, speaking generally, the rocks grow finer as we ascend, and pass from grits to fine grey slates. All the beds are repeated, so that a band of graptolitic slate recurs at each end of the cutting. Fossils were extracted with difficulty, and are badly preserved. Among the forms were *Didymograptus bifidus*, *Tetragraptus bryonoides*, *T. caduceus*, *Goniograptus sp.*, *Phyllograptus* several forms, *Dendrograptus sp.* and *Lingulocaris M'Coyi*, the horizon being thus clearly shown. The inversion can be clearly traced in several other cuttings, and in the creek sections towards Chewton, but none are so well-marked as this.

The quarter-sheets do not show that the great amount of inversion here displayed was detected. The only indication of any overturned beds that I can find is given on $\frac{1}{4}$ S., 9 S.W., near the south-west corner, where a brief note records its occurrence. This locality is nearly on the strike of Chewton and Fryers. I may say that it was on palæontological grounds that I suspected the inversion, as the succession of the graptolites was not in accord, apparently, with that near Castlemaine. From Wattle Gully to Castlemaine the beds are less disturbed, and the anticlines are more easily detected. A series of about seventy observations gave an average dip of a little over 70°, there being no marked difference between the amounts of easterly and of westerly inclination, though the general dip is westerly. How far this general westerly dip extends I cannot say. From my own, admittedly imperfect, observations, I had put the main syncline

down as about a mile and a half west of the town. Selwyn and Ulrich both state the general dip about Maldon to be easterly, and the former has placed the syncline further west near Muckleford Creek.

In a mining district, where everyone is a geologist, it is unfortunate that the geological term "dip" should be, as here, misused, and still more, used in a different sense in Castlemaine from what it is in Bendigo. The strike of our silurian rocks, both upper and lower, is constantly nearly north and south, so that in a mine we generally have two sets of workings. One set ("drives") agrees with the strike, and the other ("crosscuts") with the dip joints. Any bed or vein with an east or west inclination is said to "underlie" or "underlay," while any north or south inclination of a vein or dyke is called the "dip" at a given rate. The distinction has, of course, a practical value, or it would not be used. In the Bendigo "saddle-reefs" the miner's "dip" is the geological "pitch." In Castlemaine, a vein with a north-east dip would be said to "underlie" east and "dip" north, the true dip being resolved into two directions at right angles.

The Graptolite Succession.

Mr. G. H. F. Ulrich, in his valuable catalogue above quoted, states that "owing to the absence of distinctive beds, such as conglomerates and limestones, together with the fact, that the same genera and species of graptolites occur throughout the lower silurian series, no means at present (1874) exist for subdividing the formation." On first examining the graptolites in the immediate neighbourhood of Castlemaine, I was at once struck by the difference of the facies from the one I was already familiar with at Bendigo, and a closer examination of the district showed that there was a gradual change in the character of the fauna on going eastward. This discovery was, of course, only made after many long walks and fruitless searches for fossils amongst the rugged hills that surround the town. The spoil heaps of the gold workings, which lie in every direction, are for the most part old and weather-worn. Pyrites, and other easily decomposable minerals, have aided in the work of destruction, and it is consequently an exception to find graptolites in

these localities, sufficiently well preserved for recognition. Even when, after long practice, I was able to judge that a certain outcrop would yield fossils, a couple of hours work with the pick, often not only showed the correctness of the judgment, but also that cleavage and weathering had almost entirely destroyed the characters of the specimens. Ultimately, however, a few localities were found, from which a fair number of species were procured. The change of fauna from east to west has already been alluded to, but the work of correlating the scattered outcrops at first presented great difficulties, as they were dotted irregularly over six or seven square miles of rugged country, and I was uncertain which were the upper and which the lower beds. Fortunately my first systematic attempt was completely successful, and, as I suspected from the general westerly dip, the beds south of Chewton were the lowest. I chose an outcrop at Daphne Reef in Lost Gully, as my starting point. Here, almost on the summit of an anticline, a small excavation yields forms identical with those of the central part of Bendigo. The commonest and most characteristic form is *Tetragraptus fruticosus*. This occurs of all sizes, and some of my specimens quite dwarf all illustrations I have seen. The branches, after the outward curve, run in a straight line, and the form has the appearance of *Didymograptus V-fractus* (Salter), but its true tetragraptid nature is clearly shown in several specimens. In one example from this locality, one branch is over eight inches in length, and is broken at the distal end. I have similar specimens from Bendigo, but none so large. The anticline was traced over very rough ground, north, for three-quarters of a mile, and *T. fruticosus* was found all the way, till I found myself in Wattle Gully, to the west of another good locality. Owing to the steep slope of the ground the last part of the work had been very difficult, and I spent over an hour breaking slate, before I found the required specimen of *T. fruticosus*. This zone, the *T. fruticosus* zone, is 200 feet below the next above. The intervening rocks are clearly shown in the race, to the south, but yielded no fossils after several visits.

The second zone, just mentioned, which I worked principally from a small shaft in the South Wattle Gully Claim, is characterised by the extreme relative abundance of *Didymograptus bifidus*, which apparently ranges no higher, though it occurs

rarely in the zone below, and I have specimens from Bendigo and Tarilta on the same slab as *T. fruticosus*. I have found five outcrops of this, the Wattle Gully zone, namely, two previously mentioned near the Elphinstone tunnel, one to the south of the head of Poverty Gully, one near the head of Kampf's Gully, and this one in Wattle Gully. The Kampf's Gully outcrop is near a syncline which was traced south to near the Eureka reef, when the same relation to the *T. fruticosus* zone was again observed. A specimen of *Dichograptus octobrachiatus*, with a central disc, was secured from the lower zone at this locality. The only other specimen of this variety I found at Burns' Reef in a higher zone, and it has not hitherto been recorded for Victoria.

I have not been able to accurately trace the relationship of the Wattle Gully zone, to the next above, as a considerable thickness of sandstone intervenes, and is exposed both to the east and the west of the Chewton anticline. To the east of the head of Victoria Gully, at Nicholson's Reef, in Dog-leg Gully, and at Burns' Reef fossils occur, which I believe belong to the same horizon. There are no well-marked forms especially abundant, but the beds may be distinguished from those below by the absence of *D. bifidus*, and from the zone above by the still comparative rarity of *Tetragraptus caduceus* In default of a distinguishing species, I have called this the *Burns' Reef* zone, from the locality where I found the best exposures. At this place a thickness of three hundred feet of unfossiliferous concretionary-banded sandstone, and slate, separates it from the zone above.

This upper zone is characterised by the relative abundance of *Phyllograptus* associated with *Tetragraptus caduceus* (Salter). The former genus is abundant throughout all the beds, from this horizon downwards, but though plentiful in this zone is not found above it. *T. caduceus* ranges throughout all the Castlemaine rocks, being rare in the lowest beds, but gradually increasing in numbers and in size at the same time, as we go upwards. In the *T. fruticosus* zone it is rare and small. It is but slightly more abundant in the Wattle Gully beds, and it is not till the present horizon is reached that it becomes a dominant form. I have called this the *Phyllograpto-caduceus* zone, a useful though perhaps awkward term.

From the outcrop mentioned, west of Burns' Reef, I have traced this zone in a northerly direction as far as Donkey Gully, where it is found passing to the west of the Crown Nimrod shaft, a distance of a mile and a quarter. Another outcrop occurs in Deaf Ben's Gully, a mile to the south of Burns' Reef, but not on the same strike, as the beds repeat to the east. Another outcrop occurs in the railway cutting, twenty paces west of Ten Foot Hill Bridge, and is traceable in a southerly direction for about a mile. At the head of Victoria Gully it is found to overlie an outcrop of the Burns' Reef beds, being separated from them by a thickness of about 230 feet of sandstones and coarse grits. An outcrop is also seen on the east side of New Chum Gully, close to the Ajax anticline.

The next zone is a well-marked one. *Tetragraptus caduceus* occurs in the greatest profusion; I think fully eighty per cent. of the specimens belong to this form. Several good exposures occur, and a great part of my earliest collecting was done on the various outcrops of this zone. *Phyllograptus*, as before mentioned, has disappeared, while immediately below it is fairly abundant. One or two species of *Diplograptus* occur somewhat commonly, though rare below this horizon, together with several species of *Didymograptus* and one of *Dichograptus*, which I have not yet identified with certainty. In Victoria Gully, where a spoil-heap from a small mining shaft on the east side of the gully yielded a good collection of forms, I was able to measure the thickness separating this zone from the one below, and found it about 250 feet. This estimate was checked in the railway cutting about half a mile north, and the results were in accord, as I measured the distance west of the *Phyllograpto-caduceus* zone, and found the *T. caduceus* zone at the required spot.

The next zone contains *Loganograptus Logani* associated with numerous examples of *T. caduceus*. An outcrop occurs at the head of John o' Groat's Gully, being separated by a thickness of 300 feet from the *T. caduceus* zone below, both occurring on the same side of the same (Ajax) anticline. It is on the strike of the eastern limb of this anticline that Professor Sir F. McCoy records *Loganograptus* from Barker Street, Castlemaine. As far as I can learn the spot was in front of the Mechanics' Institute, and is now inaccessible; but in a yard behind one of the shops I

was able to obtain evidence of the existence of the *T. caduceus* zone with a dip to the east. From this evidence I looked for and found *L. Logani* a mile to the south as above indicated. *L. Logani* is abundant in this zone, and I have a doubtful fragment from the zone below.

This species has been confounded with two others from which it, however, is quite distinct. In its method of branching it is truly dichotomous, excepting as an abnormality, when a branch is occasionally suppressed, and the branches arise at no great distance from the centre. The genus with which it has been confused is *Goniograptus* (McCoy), in which true dichotomy does not occur, but as described by Professor McCoy,* each of the four main branches is angularly bent, and from the salient angles secondary branches are given off, which alone are celluliferous. A branch stripped of its hydrothecæ would have the appearance of *Thamnograptus*. *Goniograptus Thureaui* (McCoy), the type of the genus, has about forty-eight branches, is rather rare, and is confined to the *T. fruticosus* zone. Another species has from twelve to sixteen branches, and is common in the same zone but occurs, though rarely, as high as the Burns' Reef beds. An examination of a large number of specimens of the latter species leaves no doubt in my mind that it is congeneric with *G. Thureaui*, but specifically distinct. Herrman† describes and figures a species as *Dichograptus Kjerulfi* which has a similar aspect to the present form. I have not seen the central disc he describes, and the constant differences in the number, form and arrangement of the hydrothecæ show that our form is distinct from Herrman's. The method of branching is so striking in McCoy's genus that, in spite of Herrman's objection, I think it should stand, and, moreover, that Herrman's species should rank under it. The horizon he quotes for Sweden, is *Lower Phyllograptus shales*, just where it occurs with us, and there, as here, it is not associated with *L. Logani*. Mr. R. Etheridge, Junr.,‡ figures two examples which he calls *L. Logani*, but both are evidently referable to *Goniograptus*, the characters of which had not then been pointed

* Prod. Pal. Vic., Dec. V., pl. 50, also A.M.N.H., vol. xviii. (1876), p. 129.

† Geol. Mag. 1866, pp. 13, *et seq.*, transl. and abrd. by W. S. Dallas from Nyt. Mag. for Naturvid, vol. xxix.

‡ A.M.N.H., vol. xiv., 1874, pl. iii., figs. 11 and 12.

out by Professor McCoy. Fig. 11 is apparently *G. Thureaui* and fig. 12 is this new species. Etheridge, moreover, amongst other associated forms, quotes *Phyllograptus typus*, a genus which in Victoria does not range as high as the *Loganograptus* zone and *Didymo. Pantoni* (McCoy, M.S.). This latter species Professor McCoy* says is identical with Hall's *Tetragraptus fruticosus*, an identification which is frequently overlooked. Sir Frederick McCoy also records *L. Logani* from Newham,† but an examination of the specimens in the National Museum, on which this record was presumably founded, shows that they have the aspect of *G. Kjerulfi*, and the non-occurrence of *Loganograptus Logani* at Bb. 29 is also shown by the fact that *Phyllograptus typus* is also quoted by the Professor from the same locality (Bb. 29). In fact it appears that Bb. 29 is on an outcrop of the *Tetragraptus fruticosus* zone. Herrman‡ also seems to have considered the two forms as identical at one time, but to have subsequently altered his opinion. Having regard to the different horizons of the two forms, the importance of distinguishing them will be manifest.

Above the *Loganograptus* zone, my detailed observations do not extend. To the westward of Castlemaine, fossils are very scarce, a single specimen of *Phyllograptus* was gathered by Dr. Dendy, in my company, on the strike of about 200 yards west of where I have noted the occurrence of the *Loganograptus* zone, and a few specimens of *T. caduceus* from the same and other localities are almost the only identifiable fossils I have seen. The difficulties attending their discovery here, have been noted above. In his notes on the Maldon sheet, Ulrich states that the only fossil found in the silurian rocks of that district was a single specimen which he quotes as *Hymenocaris vermicauda* (Salter). Possibly this is the ubiquitous *Lingulocaris McCoyi* (Eth., Jun., = *Hymenocaris Salteri*, McCoy, M.S.). Mr. Norman Taylor also mentions§ that he has found no graptolites in the country immediately south of the Maldon strike. From Daylesford, however, twenty miles south on the same auriferous band, we find graptolites in profusion, and a small collection in the possession of Mr. John Hammerton, of Geelong, the only ones from there

* Prod. Pal. Vic.
† Bb. 29, in Prod. Pal. Vic., Dec. 1, p. 19.
‡ *Loc. cit.*
§ Rep. Min. Surv. Vic., Dec., 1888, p. 70.

which I have seen, contained the characteristic species of the *Tetragraptus fruticosus* zone. I cannot help feeling that the same zone will be found at Maldon, though the highly metamorphic character of the rocks will make the discovery of fossils difficult. My last excursion before leaving Castlemaine was made with a view of carefully searching the railway cuttings on the Maldon side of Muckleford Creek. The first likely-looking spot after leaving Maldon, however, was found only nine and three-quarter miles from Castlemaine. Graptolites were found on the first trial, but unfortunately were so decomposed that I could not identify them. Numerous small crustaceans, possibly *Lingulocaris*, also occurred. This was the only place where fossils were obtained, though the country near Fentiman's Reef would, I think, repay further search.

The Graptolites of other Localities.

The careful way in which the localities of specimens were recorded on the maps, by the officers of the old survey, and the references to those localities by Professor Sir Fredk. McCoy, in his "Prodromus of the Palæontology of Victoria," enable us to make some interesting comparisons, and, at the same time, cause us to wish that we had further elucidations of the hieroglyphics on the maps. The fauna of the lowest Castlemaine zone, which I have observed, agrees with the beds of Bendigo in a very marked manner. The Bendigo beds which I have examined most closely are in Derwent Gully, a little below where the Carshalton anticline crosses it, and at Ironbark, just west of the Victoria Quartz Mine, as well as less thoroughly at many other spots. Mr. Wm. Nicholas, F.G.S., has given me a small number of slabs of slate from near the Old Sarnia Reef at the south of the field, and all three localities agree very closely in their fauna. The agreement of an outcrop at Daylesford with this zone has already been indicated. Besides Bendigo, Professor McCoy records *T. fruticosus* from Spring Plains (Bb. 45, Bb. 46, $\frac{1}{4}$S. 13 N.E.), the Upper Loddon on the strike of Chewton and Fryers (Ba. 76, $\frac{1}{4}$S. 9 S.W.), and a couple of miles east of Gisborne (Ba. 71, $\frac{1}{4}$S. 6 S.W.) These localities then contain beds at or near the same horizon, though doubtless it will be possible for subdivisions to be made later.

With regard to the Lancefield beds, the plentiful occurrence of highly compound forms would lead us, by analogy with the succession in localities in the northern hemisphere, to place them below the lowest of all the beds dealt with. Fortunately we have evidence of a stronger character which points in the same way. A striking slender bifid graptolite occurs commonly at Lancefield, and I have found specimens at Daphne Reef, and Derwent Gully. *Clonograptus* occurs, at any rate as high as the Burns' Reef beds in Castlemaine, but is rare, while several species occur at Lancefield. The Bendigo Museum contains a fragment labelled "Bendigo," which is apparently the gigantic species described by Mr. G. B. Pritchard as *Temnograptus magnificus* from Lancefield, where it is common. In a paper read at a recent meeting of this Society, Mr. Pritchard records *Tetragraptus quadribachiatus* from the same locality. It occurs in the *T. fruticosus* zone, is very abundant in the Wattle Gully beds, and occurs, though rarely, as high as the *T. caduceus* zone. The genus *Phyllograptus* is not represented in the Lancefield beds, but is recorded by Professor McCoy not far to the westward, and on examining the specimens from this locality, in the National Museum, I detected one or two small specimens of *T. fruticosus* on one of the slabs. The evidence then points to the fact that the Lancefield beds are below the *T. fruticosus* zone, and probably at no great distance.

The graptolitic slates of Darriwill (19 S.W.) are apparently on the horizon of the *L. Logani* zone for that species and *T. caduceus* are, according to Professor McCoy, very plentiful at that locality,* and the specimens quoted are on view in the National Museum. Graptolites are recorded from many other lower silurian localities in Victoria, but till further observations are made, and more of the species are identified, it will be rash to assume any succession based solely on that of the northern hemisphere. Probably the same general succession will hold, but it is quite likely that certain species and genera will be found to have a different range in the two regions, so that inferences based on the few recorded species for these other localities may quite possibly be erroneous.

* Prod. Pal. Vic.

In New Zealand it may, however, be noted that graptolites occur, and Sir James Hector* gives some woodcuts of species found there. These are, however, not named in the work, and the figures alone merely give general characters. All the figures might be intended for forms which occur in the Wattle Gully or in the *T. fruticosus* zone in Castlemaine, and the former is the more probable horizon.

The results obtained may be tabulated as follows, the beds being arranged in descending order:—

1. Zone of *Loganograptus Logani*, occurring at Castlemaine and Darriwill.
2. Zone of *Tetragraptus caduceus*, occurring at Castlemaine.
3. *Phyllograpto-caduceus* zone, occurring at Castlemaine.
4. Burns' Reef beds, occurring at Castlemaine.
5. Wattle Gully beds, occurring at Castlemaine and (?) New Zealand.
6. Zone of *Tetragraptus fruticosus*, occurring at Chewton, Bendigo, Spring Plains, Tarilta, Upper Loddon, Daylesford, Gisborne, and to north-west of Lancefield.
7. The Lancefield shales.

With regard to the extension of the zones in the line of strike, the important effects produced by "pitch" must be recognised, as has been so fully indicated by Mr. E. J. Dunn in his "Report on the Bendigo Goldfield." There is evidently a strong northerly pitch in the great Chewton anticline, as, although I have carefully examined the area north of Forest Creek, I have never been able to find traces of any but the second and third zones. The sixth zone again occurs at Tarilta, approximately on the strike of the highest indicated zones at Castlemaine.

Auriferous Bands.—The fact that the auriferous quartz-veins of Victoria occur in fairly definite bands of country, separated by non-auriferous bands of lithologically similar strata, is one that early impressed itself on observers, and it is difficult to say who first noted the fact. Sir Alfred Selwyn records it, and Mr. Evan Hopkins† also mentions it. In a recent report of the Mining Department an old letter to the Governor of the Colony from

* Cat. Geol. Exhibit, Ind. and Col. Ex., 1886, p. 82.

† Q.J.G.S., vol. x., p. 324.

Mr. J. A. Panton, then warden of the Bendigo goldfield, shows that he was one of the earliest to point out the same fact. Mr. Wm. Nicholas, F.G.S.,* has worked these bands out in great detail; and Mr. Reginald Murray† follows out the same principles. Both of these gentlemen have, since then, repeatedly called attention to these facts as an aid to future mining operations. In the Castlemaine district the main auriferous band strikes through Fryers and Chewton, and is approximately on the same strike as the richest portion of the Bendigo field. In the former district the band is seamed with reefs that have yielded almost fabulous quantities of gold, and most of the auriferous gullies head to this line. The chief apparent exceptions to this last fact are those gullies which receive the drainage of gullies cutting through the older gravels. As we go westward from this line, and travel over higher beds, the rich reefs grow fewer and fewer, and we have no well-marked lines like the one mentioned. When we reach, what Selwyn states to be the highest beds of the district, on the meridian of Muckleford Creek, the quartz-reefs are apparently more numerous than ever, but the richly auriferous country-rock is not there to feed them, and they are barren. The quarter-sheets show that nearly every gully in this locality was carefully searched for gold by the survey party, but without result, and this for miles to the north and south. Since then the Mining Department has, by a carefully chosen series of bores, tested the deep ground of Muckleford Creek, but with a like negative result.‡ In the Lancefield rocks again, no gold occurs. It appears then, that the auriferous strata of our lower silurian rocks begin above the base of the apparently thick *T. fruticosus* zone, and range, at anyrate, as high as *Phyllograptus* does, but probably no higher. That the recurrence of the auriferous bands across the colony is due to the recurrence of the same sets of beds, is so very probable, that the idea is the common property of geologists, but no attempt has, I believe, been previously made to show how these beds might be distinguished.

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* Prog. Rep. Geol. Surv. Vic., vol. iv., p. 145.

† Geol. and Phys. Geol. Vic., p. 157.

‡ Ann. Rep. Sec. Mines, 1890.

Thickness of the Strata.—Sir Alfred Selwyn* gives a section, before noted, passing through Mounts Alexander and Tarrengower, and on the evidence of this, states that the thickness of the silurian rocks of *this district* is not less than 35,000 feet. To get this thickness on this line of section, and with the average dip he gives, no allowance can be made for repetition by folding. I cannot find that he ever gave reasons for altering his opinion on this point, but we find him in 1861 (Ex. Ess., p. 177), and again in 1866 (Ex. Ess., p. 11), applying these figures to the whole of the upper and lower silurian rocks combined. This, his more recent statement, has been generally followed and quoted. Now the west end of the silurian trough of his section is nearly on the strike of the Chewton anticline, where it runs into the granite; so that perhaps he could have calculated the true thickness of the Castlemaine series along his section line, though, from the indications of a northerly pitch, I do not think so. Since the days when Selwyn made this traverse of a difficult and practically unexplored country, and without suitable maps, great changes have taken place. Railway and road cuttings, water-races and mines have given facilities, that he was without, for examining the rocks.

The lowest beds, as shown by the presence of *T. fruticosus*, crop out near the west end of the Elphinstone tunnel, so that we have here an anticline, which, though auriferous west of Taradale, at Drummond and Lauriston, some miles to the south, is very poor in quartz-reefs, and apparently non-auriferous at this locality. A slight syncline occurs to the west, at about the meridian of the seventy-fourth mile post on the railway line, though the highest zones are missing. The crest of the next great anticline runs, as before stated, through Chewton. Selwyn places the main syncline between Castlemaine and Maldon, about Muckleford Creek. Taking this last observation of his as correct, we can calculate the thickness approximately. From the Eureka Reef, where an outcrop of the *T. fruticosus* zone occurs, to the west end of John o'Groat's Gully I have plotted all the anticlines and synclines I could detect. In this distance (two and one-eighth miles) I find :—

* Parl. Rep., *loc. cit.*, and Q.J.G.S., vol. x.

The total amount of westerly dip shown is	2376 yards.	
,, ,, easterly ,,	1364	,,
,, excess of westerly ,,	1012	,,

The mean of sixty-seven observations of dip is a trifle over 70°. If we assume this excess to be constant as far as Selwyn's syncline, and assuming the dip to be, as I believe it is, at the same rate, we get in five and a half miles an excess of 7858 feet of westerly dip exposed, which is equal to a thickness of 7500 feet. If we add 500 feet for the probable thickness exposed below the Wattle Gully beds, we may put down the total thickness of the lower silurian rocks exposed in *this district* as 8000 feet. As yet we have no means of even guessing the total thickness of our lower silurian rocks, and of the thickness of our upper silurian we know nothing.

Newer Rocks.

The only other sedimentary rocks of the district are the old and recent river gravels. Castlemaine itself is a little over 900 feet above the level of the sea, and none of the older gravels are more than 1100 feet. The latter usually occur here as cappings to minor hills, which they have protected from denudation. The linear arrangement of these hills, and frequently their relation to the present drainage system, shows them to be of fluviatile origin, and Selwyn† did not intend the general remarks he made in reference to some marine tertiary gravels to apply to this distinct, or to Bendigo, though it is often stated that he did so. Even when the relation of the old gravels to any drainage system sufficiently large for their accumulation is not apparent at first sight, the effects of denudation must be borne in mind. On this head Colonel (then Captain) Couchman, formerly Chief Mining Surveyor, makes some able and interesting remarks.* Taking most of his illustrations from this district, he shows how changes in the courses of rivers may be made, by tributary streams cutting back, and by main streams working towards the dip, till another water-shed is tapped, and the old river-bed

* Ex. Ess., 1866, p. 22. † Smyth's Goldf. and Min. Dist. of Vic., pp. 158-60.

with its gravels is left in what is, at first sight, an inexplicable position. Since he wrote, the subject has received considerable attention in the United States.*

The officers of the Survey have devoted a great amount of care to these economically valuable beds,† and have divided the gravels of this district into older and newer pliocene and recent. The evidence of the separation of the first two named, is frequently very obscure. I do not see, for instance, how the lower portion of the Forty-foot Hill deposit is classed as of the same age as that capping Diamond Hill, lower down the same stream and about eighty feet higher above sea level. The character of the deposits is described in the greatest detail by Ulrich, and it will suffice to state that all the rocks in the gravels occur *in situ* in the present water-shed, there being a preponderance of those found near the granite boundary. The indurating action of metamorphism is shown both by the range bounding the granite and by the occurrence of fragments many miles below the metamorphic zone. Slickensided fragments frequently occur, but I have not seen any examples of which could be referred to glacial action. Some terrestrial fossils are recorded on the Southern Maldon sheet from these older gravels. Amongst other specimens was an almost complete skull of *Sarcophilus ursinus*. The only organic remains I have found are a few traces of plants which were, however, quite indeterminate.

Volcanic Rocks.

Dykes of basic volcanic rock are fairly common, though very few are shown on the map, their small size and decomposed condition rendering their detection at the surface almost, if not quite, impossible. The rock contains numerous crystals of olivene and hornblende, frequently of large size. Black mica occurs in a dyke at the Eureka Reef and in one near Harcourt, at the latter place sometimes reaching three-quarter inch in diameter.‡ One dyke, six feet thick, at Burns' Reef, is traceable north for more than a mile; others occur on the west side of Wattle Gully, at the Englishman's Reef, Ajax Mine, while several are exposed in

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* Contributions to "Science," 1893, &c.

† Ulrich—Cat. Rocks, &c., p. 189, *et seq.*, and reprinted in Lock's Practical Gold Mining.

‡ See also Ulrich, *loc. cit.*, p. 35.

the railway cuttings near Chewton, and I could quote many more in the district. Lithologically, judging by hand specimens, the rock seems to resemble that of the Bendigo dykes which Mr. Howitt calls Limburgite.* At Maldon, in the Eaglehawk Mine, a beautiful green dyke-stone occurs containing massive garnet, hornblende crystals, pyrrhotite and other minerals. Mr. Pritchard tells me that Mr. A. W. Howitt, who examined a specimen for him, says the rock consists entirely of Diallage.

Mount Consultation, four miles south-west of Castlemaine, is an old volcanic neck. Very little scoriaceous material remains, and on the south side the dense basaltic rock rises almost precipitously from the silurian below. The basalt is almost black, very fine grained, rarely vesicular, and has in some places a platy structure. The divisional planes are marked by whitish bands, and have a "dip" of about 40° inwards towards the vent, as shown on an arc of about 90°. The aneroid reading gave the height as 300 feet above the Castlemaine station or about 1200 feet above sea level. What is apparently a still more denuded neck, occurs at the head of the southern arm of Diamond Gully. The surface of the rock has been denuded equally with the silurian and occupies an area of about twelve acres, the ground being cultivated. The rock is apparently similar to that of Mount Consultation, but contains numerous angular fragments of sandstone embedded in it. A quarry hole twenty-two feet deep occurs, and the owner says the rock grows denser with increase of depth. Lower down the hill a shaft was sunk to pierce the basalt; at twenty-two feet however work was suspended. The gully which heads to this outcrop received its name from the occurrence of zircons, pleonastes and other gems derived probably from the basalt itself. Gems are also recorded from the older drifts of Diamond Hill. In order to ascertain the relative age of the basalt, I tried to find whether any had been procured from the oldest drift on the hill-top, but without success.

At Guildford, at the junction of Campbell's Creek and the Loddon, we find the older drifts capped by a basalt flow which, originating near the head waters of the ancient stream, has followed its course as far as the junction of Muckleford Creek.

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* Notes on Samples of Rock, &c. Special Rep. Min. Dep., 1893, p. 1.

This flow has been denuded, and the old river course is shown by a chain of isolated flat-topped hills, known as the Loddon outliers.

Mount Franklin, twenty miles south of Castlemaine, is a well preserved cone of very recent date. The notes on the quarter-sheet (15 S.E.) state amongst other facts, that "The basaltic lava-streams of the country surrounding Mount Franklin and Franklinford are of two different ages. . . . . The more recent streams have poured into the present valleys, and in their gradual descent from the highest points of eruption have covered the post-pliocene as well as the older and newer pliocene drift. Only where they have acted as natural bars to, or lie in the line of drainage from higher levels, they are, in their turn covered by recent alluvium. The termination of the Jim Crow Creek flow is characterised by a very rugged surface and rocky escarpments, resembling the recent lava flows from the craters in the Western District." Thus we have then to the north of the Divide a very recent volcano, a fact which tends to weaken the generalisation of Professor David* that the most recent volcanoes occur near the sea coast, and the older further inland:—"The zone of volcanic activity in that country (*i.e.* Victoria) appears to have followed the southern shore-line which was constantly retreating southwards." To my mind Mount Franklin is quite as young as any of the volcanoes of the Western District which I have seen, the crater being beautifully perfect.

A dyke of grey quartz-felsite occurs in the Beehive Mine, Maldon, and several dykes are marked on the quarter-sheet. They are probably connected with the main granite mass.

In conclusion, I have to thank several of my friends in Castlemaine, including many of the mining managers of the surrounding district, for information, especially in regard to the past history of the goldfield—which has been of great service to me. My thanks are also due to Mr. A. W. Howitt, Secretary for Mines, for copies of the geological maps of the district, which have been of great use in the final preparation of my paper.

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* Proc. A.A.A.S., 1892, p. 73.

List of some of the Minerals occurring in the Castlemaine District.

Most of these have been recorded by Mr. G. H. F. Ulrich in "Exhibition Essays," 1866, and in "Contributions to the Mineralogy of Victoria," 1870. A few new localities are recorded.

U = G. H. F. Ulrich.
H = T. S. Hall.

Albin (var. of Apophyllite). In druse, Harcourt granite quarry (H.) Identified by Mr. O. Rule.

Albite.—Quartz reef, Blacksmith's Gully (U.) Quartz reef at Francis Ormond, Garfield and reefs to north, Coomb's Gully, Crown Nimrod and several other quartz reefs (H.)

Alunogen as thick efflorescence, Barker's Creek slate quarries (H.)

Amphibole (black variety). Large imperfect crystals in basaltic dyke at Eureka Reef. Granite of Mount Alexander (U). In basic dykes, Wattle Gully, Burns' Reef, &c. (H.) (Green variety): Eaglehawk Reef, Maldon; found by Mr. G. B. Pritchard, and identified by Mr. A. W. Howitt.

Amethyst.—Common in Bradford Lead: some approach rose quartz in character (U.)

Augite.—Cavities in Malmsbury dolerite (U.)

Azurite.—Nicholson's Reef, Castlemaine (U.)

Barite.—Swiper's Reef, Maldon, in saddle-shaped crystals (U.) Crystals described and figured Ex. Ess., 1866. Cymru Mine, Maldon (J. Hornsby). Rare in platy crystals in quartz, Devonshire Mine, Castlemaine (H.)

Biotite.—Basaltic dyke, Eureka Reef, Castlemaine, also Campbell's Creek (U.) Dyke, Harcourt; dyke, Burns' Reef. Mount Alexander, granite (H.)

Bismuth (native) in small grains in quartz reef. Sandy Creek (U.)

Bismuthite, drift of Sandy Creek (U).

Calcite various recorded localities. Tarrengower (Maldon), Newstead (U.), Rhombohedra, quarter inch diam., Ajax Mine, Wattle Gully Mines. Masses up to a cubic foot, Ajax. *Travertine.* Limestone Creek. Crystals lining hollow dolomitic masses, Guildford, &c. (H.)

Cassiterrite, rare in Belltopper lead, Taradale (U.)

Cerussite.—Nicholson's Reef (U.)

Chabazite in basalt, Malmsbury (U.) Beehive Reef, Maldon (J. Hornsby).

Chalcopyrite in grains quartz reefs, Castlemaine and Maldon, as a vein several inches thick, Eaglehawk Reef, Maldon (U.) Harcourt granite, in small patches (H.)

Chalybite.—Eaglehawk Reef, Maldon, as lodestone of vein of copper-pyrites. Lisle's Reef (U.) See *Dolomite.*

Chlorite.—Rare as scaly coatings, Lady Gully and Wattle Flat, Blacksmith's Gully in quartz. In slate, Yandoit (U.) Coating imperfect quartz crystals and by decomposition, giving them a roughened appearance. Quartz Reef, Upper Loddon. Identified by Professor A. Liversidge (H.)

Chromic iron impregnated in quartz and quartzose rocks, Strathloddon (U.)

Chrome ochre.—Found at Strathloddon by Mr. (Colonel) Couchman (U.)

Copiapite (?)—As brownish crusts and stains on spoil and pyrites heaps (H.)

Copper (native).—Sparingly with gold, Specimen Gully Reef (U.)

Copperas.—In crystals, Beehive Reef (U.)

Covelline.—Specimen Gully (U.) Coating chalcopyrite, Harcourt and Scotchman's Gully (H.)

Damourite.—Bradford lead enclosed in smoky quartz (U.)

Dolomite.—Crystals, Lisle's Reef (U.) Varieties of calcite containing various quantities of iron and magnesia occur in various rhombohedra in Ajax and Wattle Gully Reefs, &c. Lenticular masses, strings and veins occur in the slates at Specimen Gully, Forest Creek. A white, soft, earthy substance consisting of carbonates of lime and magnesia occurs at the Barker's Creek quarries. A magnesian-lime cement occurs in some of the old gravels (H.)

Epidote (Epidote-rock).—Dyke, two and a half miles S.E. of Tarilta (U.)

Epsomite.—Eaglehawk Reef (U.) Argus Hill Co., as thick incrustation in old drives (H.)

Galena.—In nearly all auriferous reefs (U.) In fairly large grains, Scotchman's Gully (H).

Garnet (common red).—Drift of Barker's Creek, crystals embedded in smoky quartz, Bradford Lead (U.) In diallage dyke, Eaglehawk Reef (J. Hornsby); in granite, Maldon (J. Dennant); in granite, Harcourt quarries; granitic dyke, Expedition Pass (H.)

Gold.

Graphite.—An impure graphite coats slates in vicinity of quartz reefs, *e.g.*, Ajax, Englishman's, and many other reefs (H.)

Gypsum.—Clays, Mount Consultation, Sandy Creek (U.)

Gumbelite (?)—Replacing graptolites (H.)

Heulandite.—Sparingly, as drusy coatings, Lisle's, Lennox, and Tiverton Reefs (U.)

Hyalite.—Common in dolerite, Malmsbury (U.)

Ironglance.—In tabular crystals in quartz reefs, Sandy Creek; in tabular crystals in dolerite, Malmsbury (U.)

Labradorite.—Dolerite, Malmsbury, Loddon outliers.

Limonite.—As nodular concretions and veins in silurian rocks at Fryers, Maldon, Castlemaine, as cement of older drifts (U.) Pseudomorph after cubical pyrites; Wattle Gully, Bolivia Reef, forming iridescent films on rocks, common (H.)

Magnesite concretions in various localities (U.); concretions in Kampf's Gully (H.), Maldon (J. Hornsby).

Magnetite and *Ilmenite*, as black sand in alluvial deposits draining from basaltic country (H.)

Malachite.—Nicholson's Reef (U.); small earthy patches Scotchman's Gully Reef (H.)

Maldonite.—Nuggety Reef (U.) An alloy of bismuth and gold is obtained in some mines in Maldon at times, on "retorting" the mercury.

Mispichel.—Various recorded localities, massive, and in crystals (U.)

Molybdenite.—Granite, Maldon (U.) Quartz reefs, Maldon (J. Hornsby).

Mountain leather.—Tarilta (U.) Associated with tabular crystals of calcite in quartz reef, 900 feet level, South German Mine (H.)

Muscovite.—Granite generally (U.)

Nontronite.—Maldon (U.)

Oligoclase.—Scoria, Mount Franklin; greenish, in granite, Tarrengower, Harcourt (U.)

Olivene.—Newer basalt generally. Mount Franklin ash (U.) Basaltic dykes.

Orthoclase.—Granite generally; granite boundary, Elphinstone, Maldon, Harcourt. Large crystals, Bradford (U.) Large crystals, Mount Barker and Expedition Pass (H.)

Pharmacosiderite.—In cubical crystals, Beehive and German Reefs (U.)

Pholerite.—Blacksmith's Gully (U.); Ajax and Garfield Reefs, &c. (H.)

Pyrite.—Common in cited localities (U.) Cubes, Wattle Gully, in sandstone, &c. Octahedra, South Wattle Gully Mine. Pentagonal dodecahedra, Devonshire Mine (H.)

Pyromorphite.—Nicholson's Reef (U.)

Pyrrholite.—Specimen Gully, and several Maldon Reefs (U.) In diallage dyke, Eaglehawk Reef, Maldon (H.)

Quartz.—Common as reefs, hooded quartz, Pigeon Hill (figured) crystals large, Blacksmith's Gully, &c. (U.) *Smoky quartz:* Bradford, Tarrengower (U.) Harcourt Quarries (H.) *Prase:* Lady Gully (U.), Blacksmith's Gully, Ajax Reef, &c. (H.) *Lydianite:* Veins, Joyce's Creek (U.)

Sapphire.—Common in drift, Vaughan (U.)

Scorodite.—Crystals, Beehive Reef (U.)

Selenite.—Mount Consultation (U.)

Sphalerite (Zincblende).—Nuggetty Reef (U.) With gold, Francis Ormond, and Crown Nimrod Reefs, Scotchman's Gully, Mopoke Gully (H).

Steatite, as a vein, Strathloddon (U.)

Stibnite (Antimony glance), Fentiman's and Eaglehawk Reef (U).

Stilbite, in druse, in granite, Harcourt (H.) Identified by Mr. O. Rule.

Sulphur (native) with grey antimony, Fentiman's Reef (U.)

Topaz.—Gold drifts of Castlemaine district, Bradford lead (U.)

Tourmaline. Granite, of Mount Alexander, at Maldon (U.); Expedition Pass (H.)

Wad (black ferromanganese ore), quartz reefs common, as cement of conglomerates, Strangways, Tarilta (U.)

Wolfram.—Sandy Creek (U.)

Zircon.—Gold drift, Tarilta, Guildford, Hardhills, Campbell's Creek (U.)

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EXPLANATION OF PLAN.

1. Outcrops of *L. Logani* zone.
2. ,, ,, *D. caduceus* zone.
3. ,, ,, *Phyllograpto-caduceus* zone.
4. ,, ,, Burns' Reef beds.
5. ,, ,, Wattle Gully beds.
6. ,, ,, *T. fruticosus* zone.